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DIVWAG MODEL DOCUMENTATION
VOLUME I
EXECUTIVE SUMMARY

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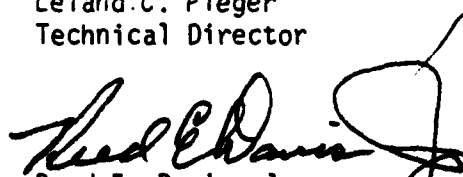
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ABSTRACT

This documentation provides a complete description
of the Division War Game (DIVWAG) Model as it exists
on 1 April 1976. The documentation is composed of an
Executive Summary (Volume I), an Analyst/Programmer
Manual (Volume II), and the Planner/User Manual (Volume
III). Described within the volumes are the model
design and development; application; capabilities;
limitations; facility, equipment, and personnel
requirements; data input requirements; mathematical
and logical processes; program descriptions; output
descriptions; user instructions; and diagnostic
messages. This documentation was originally produced
in April 1973 by Computer Sciences Corporation (CSC)
under Contract DAAG 11-70-0875.

CONTENTS

FIGURES

VOLUME I

EXECUTIVE SUMMARY

CHAPTER 1

INTRODUCTION

1. PURPOSE. The purpose of this volume is to provide a summary description of the DIVWAG Model. An understanding of the background of the model, some suggested model applications, and the composition of the DIVWAG Model are provided by this volume. The capabilities and limitations are presented in conjunction with the summary descriptions of all individual functional elements of the DIVWAG Model and a statement of the minimum computer system requirements.

2. ORGANIZATION. Three chapters follow in this volume. Chapter 2 contains a statement of the purpose of the DIVWAG Model and its suggested applications followed by a brief history of the model's development. Chapter 3 presents the model's capabilities, a summary description of each functional element of the DIVWAG Model, and the interrelationships among the elements. The final chapter specifies the minimum computer system requirements for execution of the model.

CHAPTER 2

MODEL PURPOSE AND BACKGROUND

1. NEED FOR A DIVISION WAR GAME MODEL:

a. Within the Army Planning System,[1] there are two significant planning tasks that demand the use of a credible and acceptable division war game model: objective force and resource planning, and approved (constrained) force planning. Both planning tasks contribute to the primary objectives of the Army Planning System; namely, to:

- Provide timely, pertinent Army views for consideration by the Secretary of Defense.

- Contribute persuasively to the formulation and presentation of joint military strategy, force objectives, and other matters of the Joint Strategic Planning System.

- Provide timely guidance to Army staffs and commanders.

b. Cost effectiveness studies and analyses contribute to those approved force structures appearing in the Army Force Development Plan; and, as with objective force planning, the division becomes the basic building block. A division war game model is of immeasurable value in arriving at the design and structure of the Army in the field.

c. Aside from direct application of a division war game model to the formalized Army Planning System, there is a major requirement to assess the value of competing individual systems (firepower; mobility; command, control, and communications; combat service support; and intelligence) to the overall combat effectiveness of Army forces in the field. All aspects and capabilities of these individual competing systems are studied, analyzed, and tested; however, until the systems are aggregated into a combat organization and evaluated as part of a composite system, the contribution (value) of each system to overall combat effectiveness cannot be properly assessed. The Division War Game (DIVWAG) model simulates all functions of land combat at an organizational level that permits evaluation of component organizations and systems.

2. DIVISION WAR GAME MODEL DEVELOPMENT:

a. During the late 1960s a war game model, DIVTAG II (DIVision Through Army Group), was developed for U.S. Army Combat Developments Command (USACDC) and exercised under the sponsorship of the USACDC Institute of Combined Arms and Support (USACDCICAS). DIVTAG II was recognized as a major developmental effort incorporating several potentially significant features, including the DIVTAG Scenario Language (DSL), which allowed gamers to formulate their game period plans and orders in English-like commands for communication to the DIVTAG II computer submodels.

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b. Experience in use of the DIVTAG II model to generate game data for analysis determined that the DIVTAG II system--including both human and computer elements--functioned far too slowly to be an effective tool for responding to USACDC force analysis requirements. In addition, several flaws were suspected in the application of DIVTAG II algorithms to the simulation of combat reality.

c. On 10 August 1970, the Combat Developments Research Office of Computer Sciences Corporation (CSC-CDRO) initiated Project 3-71, Improvement of the ICAS War Game Model (IMPWAG) under Contract DAAG11-70-C-0875. The overall tasks of this project were to identify deficiencies and problem areas in DIVTAG II through a review of the documentation; to establish a priority list for correction/resolution of the deficiencies and problem areas; to correct or improve DIVTAG II within project constraints; and to document corrective action, improvements, and resolutions, as well as recommended follow-on corrective action. This project was completed on 15 May 1971.

d. In February 1971, project tasking was issued to CSC-CDRO to design, develop, and validate:

(1) A computer-assisted war game model(s) which would permit determination of the impact on force effectiveness of changes in the mixes of major weapons and other systems at an appropriate level of resolution.

(2) An analytical methodology for analyzing the output of the model(s) developed and determining the effectiveness of a single force.

(3) An analytical methodology for comparing alternative forces.

The project described above is entitled "Development of a Division War Game Model (DIVWAG)" and was completed 31 December 1971.

e. On 15 November 1971, CSC-CDRO initiated Project 2-72, Improvement of the War Gaming Capability (WAGCAP), the objectives of which were to:

- Incorporate selected improvements and additions into the DIVWAG Model

- Train a government team in the major aspects of the application of the model to include associated analytical methodologies.

The project was completed on 15 July 1972.

f. The DIVTAG II model and its successor, the DIVWAG model, were programmed to execute on the Control Data Corporation 3300 series computer system at Fort Leavenworth, Kansas. They contained numerous machine-dependent programming features. In July 1972, tasking was initiated under Project 1-73 to reprogram the DIVWAG model to conform with newly established U.S. Army software development standards. The model would thus be readily adaptable to many computer systems available to the government, and fully operational on the Control Data Corporation 6500 series computer system installed at Fort Leavenworth, Kansas, in November 1972. The project included fully documenting the DIVWAG model and

performing benchmark validation. The DIVWAG documentation set dated August
1972 was produced as a result of Project 1-73. The documentation was sub-
sequently revised by CSC-CDRO in mid-1973. That revision forms the basis
for the current documentation update.

3. GOVERNMENT APPLICATIONS AND IMPROVEMENTS. The *War Games Division, Combat
Operations Analysis Directorate, US Army Combined Arms Combat Developments
Activity (CACDA)* began operation of DIVWAG in mid-1973.

a. The first operational game played with the DIVWAG model was the
Conceptual Armored Division (CONAR) study, which began in May 1973 and con-
cluded in September 1973. With its completion, a study was undertaken to
evaluate the Family of Scatterable Mines (FASCAM). This effort required
extensive modifications to the Ground Combat Model as well as some modifi-
cations to most other submodels. FASCAM was completed in June 1974. In
October 1974, a short-term Antitank Weapon Mix study was begun, being com-
pleted in January 1975. The Integration of Intelligence from All Sources
(IIFAS) study was conducted from April 1975 to September 1975. Support was
provided to the Antiarmor Systems Program Review (ASPR) from January 1976 to
April 1976. The LEGAL MIX V (Phase I) study effort began in April 1976 and
continued through August 1976.

b. In June 1974, the DIVWAG Model Maintenance Branch began a systematic
model improvement effort, specifically designed to: (1) improve model
efficiency; (2) improve model realism; (3) update the documentation; and
(4) improve model input/output. The following subparagraphs describe
generally the DIVWAG model improvements identified and accomplished by the
Model Maintenance Branch. These changes are included, as appropriate, else-
where in the DIVWAG documentation.

(1) Efficiency. The task identified by Model Maintenance as having the
most importance was that of model efficiency. During the FASCAM study,
the wall clock to game time ratio varied from 5:1 to 10:1, which was clearly
unacceptable. Several tasks were identified to aid in the solution of this
problem.

- Use of Extended Core Storage (ECS).

- Improvment of the logic efficiency in the program code.

- Use of common data areas for frequently utilized data.

- Barrier location.

- TRANSFER/JOIN cleanup.

- Segmented loading versus overlay loading.

(a) Extended Core Storage (ECS). The use of ECS became possible with
the arrival of the ECS hardware at the Fort Leavenworth Data Processing

Field Office (DPFO) in April 1974. Programs were written to place DIVWAG's unit status file (File 1), for resolution units only, in ECS. Since approximately 20 percent of all data file accesses were to File 1, the decrease in the wall clock to game time ratio was significant: approximately 20 percent. It was not necessary in this endeavor to pack the unit status file; that may, however, become necessary in the future as utilization of ESC by other users increases.

(b) Improvements in coding. Selected routines were examined based upon their frequency of use. The objective was to streamline the computer programming and thus reduce the time spent in these routines. The Event Sequencing routines, MINUET, and INITIAL were complete rewritten to accomplish this objective. In addition, several routines were combined with their calling routines to reduce computer time; specifically, CCOLF (countermortar/counterbattery) was placed in the same overlay with the Artillery model, and several small utility routines were combined within the Intelligence model. The overlay structure of DIVWAG was also investigated. Specifically, the Intelligence model was removed from the MAIN overlay and placed in a separate overlay, and all overlays were placed on the faster 844 disk devices. With the arrival of SCOPE 3.4.2 at the DPFO, buffers for the two period processor output tapes became unnecessary. The space created in the MAIN overlay by the deletion of the tape buffers and by the removal of the Intelligence model permitted the creation of additional common data areas. Reductions in DIVWAG running time are hindered by the large quantities of data accessed from an external disk device. Reduction in both the number of disk accesses and the quantity of data transferred would decrease wall clock to game time ratios significantly.

(c) Use of common data areas. Upon receipt of a report from the omnibus contractor (Braddock-Dunn-McDonald) (BDM) concerning improving the efficiency of CACDA's large simulations, Model Maintenance was able to identify candidate data areas to be included in common blocks. The BDM report contained annexes with five timing runs which provided numbers of data file accesses. By examining the frequency of file use and the routine logic, six areas were determined to be most viable candidates for incorporation into common areas. The amount of data to be shifted was limited by the general restriction (self-imposed) to remain below 130k8. The areas were:

. COMEQT   Equipment categories

. COMUTSR Constant data for UTSR (INCS)

. COMINCS INCS data (report numbers, penetration limits)

. COMZONE Battlefield geometry data

. COMTACF Tacfire dynamic data and weapon parameter data

. COMENGR Engineer model

2-4

Both Common One and Common Two (already existing commons) were restructured also as a result of the incorporation of the new common areas. With these common areas defined and implemented, and utilizing ECS, timing tests revealed a reduction in input/output (I/O) time of approximately 40 percent. At the same time, benchmark tests revealed an overall reduction in wall clock to game time ratio of nearly 50 percent. The ratio experienced was in the vicinity of 3:1 with one full division engaged against two aggressor divisions.

(d) Barrier location. The task of locating barriers by the terrain cells in which they reside, rather than utilizing the cumbersome quadrature scheme then extant, was given to the contractor (BDM) as part of a study to improve the Engineer submodel. The Study Directive for this work was received by the contractor on 20 August 1974.

(e) TRANSFER/JOIN and segmented loading. Segmented loading as an efficiency technique and the improvement of routines TRANSFER/JOIN (extremely slow but infrequently used) were not attempted due to time and resource constraints. However, TRANSFER/JOIN now executes with less CP time by rearranging the data files during start of game processing, thus reducing the amount of data to be shifted during TRANSFER/JOIN execution.

(2) Model Realism.

(a) The second major area of improvement was that of model realism. In this category were a large number of tasks, most of which had been identified during the FASCAM game. As a starting point, operational and sensitivity testing of three submodels was necessary: Nuclear Assessment, Airmobile, and Area Fire. The Nuclear Assessment model had been used only once, approximately 18 months earlier; and the Area Fire model required fine-tuning as a result of questionable artillery losses incurred during the FASCAM game.

(b) The Nuclear Assessment model testing revealed several deficiencies. The major of these was a discrepancy between the data load program and the model in relation to the height of burst and damage radius values. Assessments were negligible until the discrepancy was rectified, after which the assessment portion functioned properly.

(c) The Airmobile model test was conducted in conjunction with the gamer training classes. The only problems encountered were input data discrepancies.

(d) The Area Fire model sensitivity testing revolved about what appeared to be excessively high losses, especially to equipment items. It was initially discovered that the gamer input data for lethal areas, although coming from the LEGAL MIX studies, had assumed nonforested terrain. Since the same studies also provided forested lethal areas, tests were run in which lethal areas were reduced if the target were in forested terrain.

Resulting losses to artillery obviously dropped. A second contributing
factor was again input data, this time the size of the platoon areas the
model uses. This factor, however, had little impact on resulting losses
and was, therefore, not altered. Investigation remains to be made on the
determination of a lower bound for the platoon areas as a function of total
unit rectangle size.

(e) A year earlier, at the end of the DIVWAG development contract per-
iod in August 1973, Computer Sciences Corporation (CSC) produced a new,
improved mortar routine for use within the Ground Combat model. The mortar
logic then existing was ineffective; virtually no casualties were produced.
The new logic was designed to portray more realistically the detection of
personnel targets and subsequent firing of mortars. This logic was not
integrated into the Ground Combat model or tested due to more pressing
requirements in preparation for the FASCAM game. The successful integra-
tion and testing was conducted in June 1974.

(3) Documentation. The documentation of the changes made for the
FASCAM game was a major undertaking. The entire Ground Combat model
chapter was rewritten, as was the Air-to-Ground model chapter. Portions of
the Combat Service Support model documentation, the data load documentation
(mine load, countermeasure load, end card standardization), the DSL docu-
mentation (FASCAM fire and emplace orders), and the battlefield geometry
documentation were rewritten. Then changes in the documentation associated
with the model modifications produced in the summer of 1974 are now
included in the documentation. All new documentation as a result of the
summer 1974 efforts and subsequent changes is labeled "April 1975."

(4) Input/Output. The fourth major category to be addressed was that
of improving gamer turnaround/accuracy. Two separate areas were improved:
data loading and gamer reports.

(a) DIVPREP was modified to incorporate the specialized data load
programs for mine load, countermeasure load, and area fire platoon areas
load. In addition, all end cards were standardized to "9999," and card
images were printed in those loads that previously did not display that
information. The Intelligence and Control model load was modified to per-
mit reloading the data during a game; this feature was supposed to be in
the model according to the documentation but in fact did not exist. Two
other tasks were initiated concerning data input: one concerning TACFIRE;
the other, elevation. At the suggestion of a gamer, a scheme was developed
to simplify the input for the TACFIRE model. The scheme was to associate
weighting factors with various criteria, such as target type, target size,
target proximity. The simplicity of this scheme allows the gamer the flex-
ibility of changing the importance attached to the various factors during
a game. The elevation data problem consisted of the inability to load any
elevation data other than that provided by CSC. The capability was needed
to read a Defense Map Service tape, extract the desired elevation data,
and place it in DIVWAG's elevation data file. Both tasks were initiated

but not completed due to lack of personnel.

(b) The improvement of the gamer postperiod reports was an attempt
to provide the gamers with more informative, consolidated output to enable
them to analyze more accurately and rapidly the results of one game period
and prepare inputs for the succeeding period. Two tasks directly impacting
on this effort were the improvement to the intelligence report and the
development of two new output reports, one for air-ground activities, the
other for ground combat activities. The intelligence report was expanded
to include the reporting unit of the sensor detecting the target and the
items detected. The air-ground report consolidated air unit events and
permitted the gamers access to this information, which previously was not
available to them. The ground combat report consolidated Ground Combat
model activities by battle, by attacker-defender pair, and by battle
increment. This report contained initial and objective locations, percent
of the unit engaged, forestation and roughness indexes, losses to the eight
weapon systems, and barrier/minefield identification if one was encountered.

(c) In August 1974, Braddock-Dunn-McDonald Corporation, (BDM), the
TRADDOC Omnibus contractor, was given a contract to improve the DIVWAG
Engineer and Movement model. This $65,000 project was completed in
September 1975. Successful integration and debugging has not been completed
as of July 1976, and the documentation does not reflect BDM's modifications.

CHAPTER 3

SUMMARY DESCRIPTION

1. MODEL OBJECTIVE. The DIVWAG Model was developed as a computer-assisted war gaming system for use in simulating military interactions between opposing division-size forces and their major elements, with outputs permitting evaluation and comparison of the combat effectiveness of such division forces. The DIVWAG Model objective is to provide means for determining the impact on force effectiveness of changes in the mixes of major weapons and other systems. The DIVWAG Model permits two-sided simulations. The games using the DIVWAG Model can be open, semi-open, or closed. The games will be basically rigid, but the model can be operated with semi-rigid intelligence and special weapons assessment. Resolution is partially adjustable. Time resolution may be as small as a hundredth of a minute (0.01 minute), space resolution as small as one meter, and unit resolution as small as one individual; however, for practical gaming purposes, unit resolution is on the order of a battalion, depending on terrain scale and size forces being gamed.

2. MODEL CAPABILITIES. The model capabilities are discussed in terms of operational capabilities and operational scope.

a. Operational Capabilities. The DIVWAG Model has the following operational capabilities:

(1) Producing data for use in evaluating effectiveness of forces composed of maneuver units and their associated combat support and combat service support units.

(2) Producing data for use in the development of doctrine for the employment of land combat forces.

(3) Producing detailed quantitative data for use in comparing the effectiveness of the alternative forces.

(4) Simulating high and mid-intensity conflict (nuclear and conventional war).

b. Operational Scope. The DIVWAG Model scope is defined in terms of command levels, military services, types of operations, geographical areas of operations, rate of operation, and combat functions.

(1) Command Levels. The DIVWAG Model has been designed to produce data to evaluate division forces; i.e., a division plus an appropriate slice of corps or field army troops. There is explicit representation of the task organization of the forces. Echelons of command are defined, and reports are prepared that reflect the status of each command echelon and include the aggregated status of all subordinate units. Communications are simulated between division, brigade/regiment, and battalion command units. A total of 1000 units can be played, divided among Red and Blue forces. These units must be structured into task organizations for each force.

3-1

(2) Military Services. The DIVWAG Model has been designed to accommodate and integrate all types of land forces (e.g., armored, mechanized, and airmobile) and supporting tactical air forces.

(3) Types of Operations. The DIVWAG Model provides for representation of the major types of military operations; i.e., offensive, defensive, retrograde (delay/withdrawal), covering force, and movement. In addition the model is capable of simulating high and mid-intensity conflict (nuclear and conventional war).

(4) Geographical Area of Operations. The DIVWAG Model can accommodate rectangular geographical areas as large as 8,000 kilometers on a side. The system is limited in its application to worldwide geography only by availability of appropriate input data.

(5) Rate of Operation. The rate of operation of the DIVWAG war game is not firmly established. It is estimated that the simulation model can produce game period turnaround data in a 2:1 ratio of computer time to combat time simulated for a relatively straightforward combat situation at a battalion level of resolution. Actual timing is a function of the level of resolution being gamed, the number of units being gamed, the level of military activity portrayed, and the nature of other computer jobs on the system when the model is being used in a multiprogramming environment. Considering the time required for period turnaround, a real time to game time pace of approximately 5:1 is considered reasonably attainable for gaming at a sufficient level of complexity to provide useful results.

(6) Combat Functions. The DIVWAG Model can address the following functions and evaluate the contribution to force effectiveness of varying the mixes of related elements:

(a) Intelligence functions; surveillance and target acquisition.

(b) Command, control, and communications functions; decision and communications delay times.

(c) Firepower functions.

(d) Mobility functions; aerial, ground, and firepower mobility.

(e) Combat service support functions; supply and transportation; loss, expenditure, and consumption rates; personnel replacement.

3. FUNCTIONAL COMPONENTS AND CAPABILITIES. Functionally the DIVWAG Model is a dual system; it functions physically/electronically as a data processing system and, at the same time, it functions in simulation as a military combat system. To be complete, a description of the model must consider both aspects. The DIVWAG Model is described herein in terms of its data processing functional components and its military simulation functional capabilities.

a. Data Processing Functional Components. The DIVWAG software is divided functionally into five processors that communicate with each other through common files and records. Designations and functions of these processors are described below.

(1) Constant Data Input Processor. The Constant Data Input Processor receives data on cards, edits the data, and assembles the data onto tape and disk files. *This processor creates the model data base.*

(2) Orders Input Processor. The Orders Input Processor receives player operational orders in semi-military language and processes these orders into detailed instructions to the units simulated.

(3) Period Processor. The Period Processor receives translated player orders and simulates the military action.

(4) Period Output Processor. The Period Output Processor receives results from the Period Processor and compiles specific reports and gross summary reports used by the player to plan subsequent game periods.

(5) Analysis Output Processor. The Analysis Output Processor receives detailed data from the Period Processor as period history tapes; retrieves, arrays, and performs the statistical analysis of the data; and outputs the arrayed data in specified formats.

(6) Data Flow. The flow of data between processors and to the gaming staff and analysis team is displayed graphically in Figure 3-1. The input and output of each processor are tabulated in Figure 3-2.

b. Military Simulation Functional Capabilities. The Period Processor simulates an extremely broad and flexible spectrum of military activity through four categories of models (intelligence and control, firepower, mobility, and combat service support). The models are described individually in the following subparagraphs.

(1) Intelligence and Control (INC). This model provides the quantitative data necessary for evaluation of the contribution of sensor mixes to force effectiveness. It integrates the closely related functions of surveillance; target acquisition; combat intelligence; and command, control, and communications. Gamers are permitted to input intelligence from sources not simulated by model components. The information obtained from sensors and from gamer input is processed and used automatically by the Intelligence and Control Model to make requests for fire support on acquired targets. Fire missions are requested from available attack helicopters, Air Force close air support (CAS), or ground-based artillery by use of a set of decision rules, according to the situation. Sensor information is also converted into general intelligence by this model to produce a summary report at the end of each game period. The summary outlines the current status of what may be known at division level concerning the size, type, and location of the enemy forces in the battle area. This report is to aid the gamer in preparing orders for the next game period. The Intelligence and Control Model consists of three interrelated submodels: Collection, Processing, and Decision. The military functions simulated by the Intelligence and Control Model are summarized below and include:

(a) Sensing and Reporting. The capabilities of individual ground and aerial sensors are considered to simulate the detection and collection of information or intelligence on units of the opposing force and the summarizing

3-3
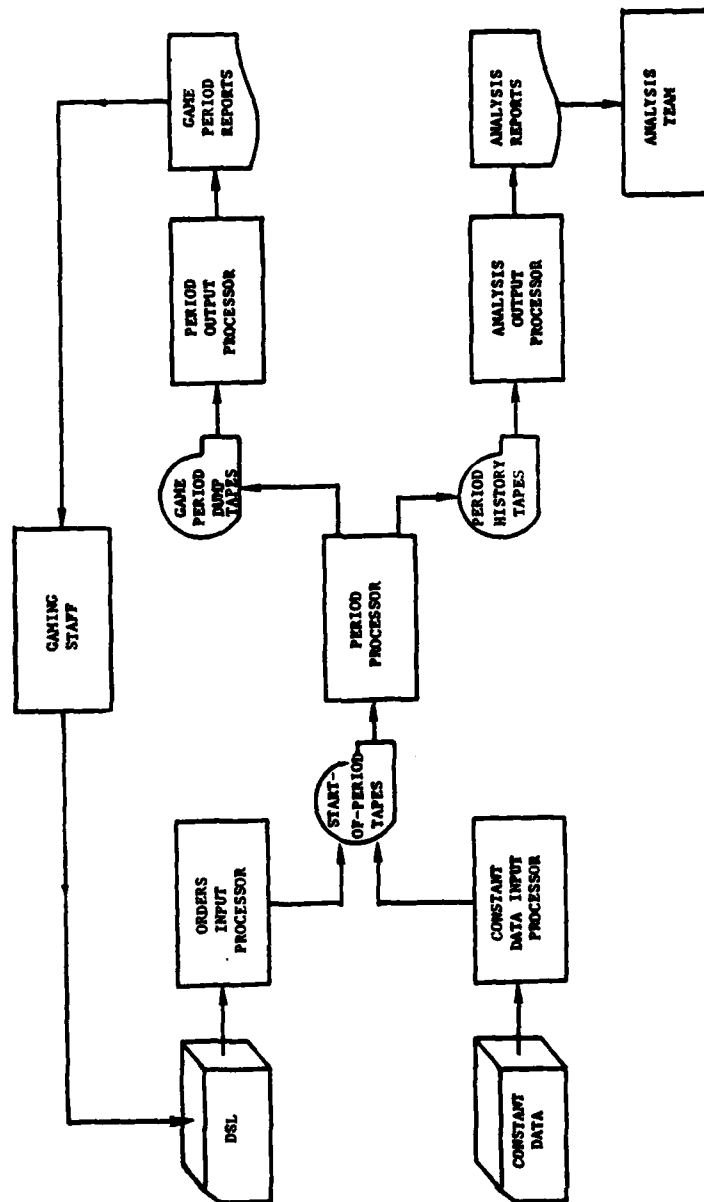
Figure 3-1. DIVWAG System Data Flow

Processor	Input	Output
Constant Data Input Processor	Constant Data Cards	Formatted dumps of data files.
Orders Input Processor	DSL Order Cards	Unit and battle order tables.
Period Processor	Start-of-Period Tapes	Game Period History Tapes, Game Period Dump Tapes, printed output from the processor.
Period Output Processor	Game Period Dump Tapes	Game Period Status, Activity, Intelligence and Barrier Reports.
Analysis Output Processor	Period History Tapes	Analysis Reports

Figure 3-2. Processor Input and Output

of such information into sensing reports, which enter the intelligence chain. Both target and nontarget intelligence are simulated. Type sensors modeled include moving target indicator radar, unattended ground sensor fields, countermortar and counterbattery radar, air defense radar, visual observers in light observation helicopters and fixed wing reconnaissance aircraft, surveillance aircraft (Mohawk type) with moving target indicator radar capability, and high performance reconnaissance aircraft with visual and various photographic capabilities.

(b) Time Delays. The model introduces separate delays for time consumed in each of the principal steps: intelligence collection, intelligence analysis, routing, and use of the information in decisions.

(c) Development of Targets for Fire Missions. A separate channel for development of target intelligence is simulated by the model. This channel provides acquired targets for fire missions without the relatively long delays involved in general intelligence processing.

(d) Intelligence Analysis and File Maintenance. Comparison of a new report with information already in the intelligence files is simulated, and if reports relate to the same unit they are consolidated. The existence of new units or parent units can be deduced. Intelligence analysis centers are simulated for each unit at maneuver battalion, brigade or regiment, and division levels. Files are designed to stay within the limits of 10, 20, and 100 reports, respectively, for these three echelons.

(e) Decisions on Information/Intelligence Flow and Requests for Fire Support. The routing of information or intelligence among intelligence analysis centers and command elements at the three echelons is simulated with the use of a flow structure and set of routing criteria, according to the information in each report. A similar set of criteria is used to determine whether a target qualifies for fire support and what type of fire support (attack helicopter, TACAIR, ground-based artillery) will be requested.

(f) Contents of Intelligence Report. The end-of-period contents of the division intelligence file are used for this report. Each report that met criteria to reach this file and was not discarded from the file in favor of a more recent record or consolidated into a record of a parent unit is reflected in the Intelligence Report. Items of estimated information given in the report for each opposing unit in this intelligence file include size, activity, type, direction of last move, time last sensed, and number of sensings attributed to this unit.

(2) Firepower. The firepower models provide the quantitative data necessary for evaluation of force effectiveness as a function of changes in mixes and types of major weapon systems. The models integrate all aspects of mid or high intensity combat where interaction of opposing forces may occur and result in personnel or materiel losses. The firepower models coordinate and integrate the effectiveness of combined arms teams by modifying assessment routines for high attrition events to account for concurrent and parallel killing capabilities. For example, when units are engaged in combat, kills are

related to the number of fire elements on opposing sides. Should an attack helicopter fire team make an attack during a ground combat cycle, the ground combat cycle will be interrupted immediately prior to the helicopter attack, the status of the units in ground combat will be updated to that moment, the effects of the helicopter attack on the current ground combat unit's status will be assessed, and the ground combat cycle will be resumed. The same assessment technique is followed for other interfacing firepower activities. Five models simulate the firepower function: Ground Combat, Area Fire, TACFIRE, Nuclear Assessment, and Air Ground Engagement. Each of these models assesses damage inflicted and produces loss, expenditure rate, and consumption data for use in evaluating the supply and transportation systems.

(a) Ground Combat Model:

1. The Ground Combat Model represents the interaction between the direct fire weapons of opposing maneuver units engaged in ground combat.

2. The model represents the interaction and the effects of weapons of cross-reinforced units. Combat power may be enhanced by employing combined-arm forces against the enemy. The effectiveness of the maneuver unit is largely dependent on the combination and coordination of weapon systems within the unit. The distance of separation of weapon systems is limited so that mutual support is possible when weapon density permits.

3. The impact of the environment is represented by the model. All movement in ground combat is subject to the constraints imposed by the environment wherein ability to move forces by ground is degraded by the effects of adverse weather, terrain, and visibility. The application of firepower is largely controlled by the environment since effectiveness of each weapon system is limited by its associated target acquisition capabilities. Target acquisition cannot occur unless line of sight exists between the observer and target. Line of sight may be severely limited due to terrain roughness, vegetation, and forestation. A firer may lose line of sight on a moving target before firing a round. A moving target may drop out of line of sight during the time of flight of the round. Target acquisition is limited by visibility, whether due to adverse weather or night combat operations. Under conditions of reduced visibility, target acquisition is enhanced by the employment of night vision equipment.

4. The interaction of each maneuver unit with the enemy is considered by the model in terms of a maneuver unit's effectiveness and vulnerability. The maneuver unit's effectiveness is influenced by the level of activity. As the level of activity increases, more weapon systems can acquire targets. As individual moving weapon systems stop to fire, the signature (i.e., evidence of that weapon firing) increases with the level of activity. The maneuver unit's vulnerability is influenced by the level of activity. A firing weapon system may disclose its position and become a target for enemy fire.

5. The Ground Combat Model relies heavily on the existence of data to describe weapon/ammunition effectiveness against varying target

types in a combat situation. The model also requires adequate data to describe the target acquisition capabilities of all employed sensor types other than unaided vision.

(b) Area Fire and TACFIRE Models. The Area Fire and TACFIRE Models simulate the scheduling of nonnuclear munitions for area fires, and the delivery and assessment of results of nonnuclear fires. Area fire events are generated by two methods. First, gamers issue fire orders prior to the engagement period for fire with specific ammunition at apsecific coordinates. Second, during the engagement period target information is developed by the Intelligence and Control Model with a request for nonnuclear artillery fire, and the TACFIRE Model automatically schedules the required fire missions for the fire units. The automatic mode is referred to as the TACFIRE mode. Targets in this mode consist of targets of opportunity and are limited to those enemy units detected and processed by the Intelligence and Control Model. Fire units are battalion or battery size, and integral fire units are used in attacking area fire targets. The fire units are constrained by range limitations, volley firing times, number of tubes or rails per fire unit, and weapons/munitions availability. A target threat priority value ranging from 1 to 9 is assigned to each area fire target, and is based upon its estimated size, type, activity, range, and the tactical doctrine used in artillery employment for the particular game. Priority one is a higher priority than priority two, etc. If a backlog of targets exists, targets are engaged in highest priority order. The Area Fire and TACFIRE routines are separated into three functional classes: scheduling, delivery, and assessment. Most of the routines for the automatic TACFIRE mode are concerned with scheduling of fires. The delivery routines deliver the munitions on target and determine units whose presence in the impact area will require assessments. The assessment routines then calculate the effects of the fire events, based on number of rounds fired, lethal area of nonnuclear munitions, dimensions of the target, number and density of target elements, and target vulnerability. The assessment routine makes adjustments in target personnel and equipment to reflect losses and in the fire unit's munitions on hand to reflect expenditures.

(c) Air Ground Engagement Model. The Air Ground Engagement Model simulates for both opposing forces all air-to-ground and ground-to-air interactions falling within the definition of close air support (CAS) and otherwise directly related to ground combat operations. These operations include aircraft fires provided by other Services, and Army aircraft delivering direct aerial fires (DAF). The Air Ground Engagement Model determines all attrition and casualty results of such interactions. The Air Ground Engagement Model is sufficiently flexible that major changes in aircraft characteristics, quantity or mixes of the major weapon systems, or their modes of employment will be reflected in the measures of force effectiveness. Single or multiple aircraft flights are generated by the Intelligence and Control Model or are directed by gamer orders. Attrition of aircraft while in flight is based on the location of air defense capable units; i.e. units that contain air defense weapons. The Air Ground Engagement Model divides the flight path into the following segments as appropriate: airbase to safe point, safe point to target, target to safe point, and safe point to air base.

3-8

. Selects from available aircraft and munitions types those
best suited for the mission, determines the time required
for aircraft preparation and pilot briefing, and schedules
the time for aircraft to be airborne.

. Maintains a current status record for aircraft assigned to
a mission, to include munitions and fuel, aircraft losses
caused by enemy activity, and effects of the aircraft on
enemy targets.

. Moves the aircraft progressively along the mission segments,
assessing aircraft status,[1] attrition, and accomplishments
at the completion of each segment to determine if the mis-
sion should continue.

. Determines the results of attacks on targets in terms of
aircraft losses and target losses.

. Upon completion of the mission and return to the airbase,
aggregates total mission results (including total mission
time), assesses aircraft damage, and determines delay times
for subsequent mission availability of the aircraft.

(d) Suppression Model. The treatment of suppressive effects of
area fires or aerial strikes upon a unit was introduced to the DIVWAG Model
through the addition of a Suppression Model. This model represents suppres-
sive effects by the interruption of selected activities (unit movement, deliv-
ery of area fires, delivery of air defense fires) in response to incoming fire.
Length of interruption depends on the activity interrupted and nature of fire
received, and the interruption is extended as fires continue to be received.

(e) Nuclear Assessment Model. The Nuclear Assessment Model simu-
lates the delivery of and the assessment of results of tactical nuclear fires.
All nuclear fires are conducted in response to gamer fire order, issued prior
to the simulated engagement period. The gamer fire order specifies the unit
to fire, weapon and munition to fire, yield, height of burst (if controllable),
and designated ground zero. Thus, all planning of nuclear fires must be car-
ried out by the gamer prior to an engagement period. In response to a nuclear
fire order, the Nuclear Assessment Model simulates the actual firing, the
nuclear detonation, and the assessment of effects against all units as well
as on obstacles and facilities within the effects area of the round. The
detonation and effects of atomic demolition munitions (ADM) are also simulated
by the model. Simulated effects include those due to blast, prompt nuclear
and thermal radiation, and delayed effects due to induced radiation. Fallout
effects are not simulated.

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1. Includes effects of air defense activities, weather, and terrain.

(3) Movement Model. The Movement Model represents unit movement other than airmobile operations including the effects of those activities that serve to improve or impede movement. The Movement Model provides the quantitative data necessary for evaluation of force effectiveness as a function of ground movements, and the related effects of significant changes in the mixes and types of mobility means. The Movement Model considers the following aspects of force mobility:

(a) Air Movement. The Air Movement section of the model simulates moves by aircraft not in connection with airmobile operations. Air movements may be ordered externally by gamers or generated internally by the Air Ground Engagement Model. Aircraft availability, class IIIA supplies, and weather limitations are checked before the air movement is allowed. Air routes, altitudes, and speeds are specified by the gamer order or are determined by the model generating the movement internally. Once tha air movement is initiated, it will be completed unless terminated due to losses. At the end of each flight segment the unit will be updated to reflect losses of aircraft and personnel and the status of associated supplies.

(b) Ground Movement. The Ground Movement section of the model simulates moves by surface transportation. Ground movements of units not engaged in combat are ordered by gamers. Ground movements are affected by category of move, unit mission, formation type, vehicle mobility characteristics, terrain conditions, daylight or darkness, road nets, weather, natural obstacles, and enemy created conditions. The maximum movement rate for a unit is the rate of the slowest type vehicle in the unit. Some of the other characteristics of ground movement are indicated below.

1. Administrative/Supply Movements. Administrative routes are generated by gamer orders; supply routes, by the Combat Service Support Model. The road movement rate depends on road type, grade, weather conditions, and nighttime or daytime conditions. Administrative movements are executed in segments determined by terrain cell boundaries or en route obstacles. Units are halted by events scheduled for the moving unit and by encountering obstacles. After the delay, the unit is not able to make up this lost time but continues to move at its appropriate rate.

2. Tactical Movements. Tactical routes are generated by gamer orders and are executed in segments in the same manner as administrative movements. Starting times and normal tactical movement rates are specified for each unit type for attack, withdrawal, and reinforcing missions, as well as for day or night movements. Units are halted for obstacles or minefields. After such delay, tactical units attempt to make up the lost time, and move at the limiting mobility class rate for that purpose. The limiting mobility class rate depends on terrain roughness and vegetation, slope and soil trafficability, forestation, weather conditions, and nighttime or daytime conditions. Each equipment type is assigned to a mobility class, and only those mobility classes used during tactical movements are considered for determining the limiting mobility class.

_3_. Maneuver Movements. Maneuvering weapon systems execute their movements at maximum limiting mobility class rates. Since different weapon systems have different maximum rates, and since the movement rate of a maneuvering unit is limited by the rate of the slowest weapon system, faster weapon systems have periods of time when they are stationary. Maneuver movement is controlled entirely by the Ground Combat Model, which determines detection capabilities, vulnerability, and weapon system capabilities.

(c) Stay Activity. The model also simulates stationary activities for all gamed units not engaged in other specified activities; i.e., all units that are not performing another military activity such as firing, moving, or combat. Whether or not addressed by gamer orders, an inactive gamed unit will consume classes I and III supplies and can be assessed as to losses and status; other units can gain information about the inactive unit. If a unit has completed all its orders before the end of a game period, the unit will automatically stay until the end of the period. Stay activity orders can be written to command ground units to remain in position for a specified length of time or until a specified game time arrives.

(d) Engineer. The Engineer Model simulates the scheduling and execution of engineer activities associated with the construction and destruction of obstacles and facilities. The model accepts engineer tasks, assigns task priorities, determines task feasibility, mobilizes mission units to execute the tasks, simulates the engineering activity in terms of time and materiel resources used, and demobilizes the mission units.

_1_. Obstacles and facilities are parts of an overall barrier plan developed for the game being conducted. Engineering activities can be initiated by gamer order to start work on a specified obstacle or facility or by request from the Movement Model when some engineering activity is necessary for the conduct of a directed movement. Where the engineer activity is requested by the Movement Model, the moving unit is unable to complete its move until the engineer activity is completed.

_2_. Engineer task priorities are based primarily upon the urgency of the activity in terms of its impact on the force's overall plan of maneuver. Task feasibility is determined in terms of task site (proximity to FEBA) and time and materiel availability.

_3_. The Engineer Model automatically allocates resources to each feasible task, constructs a mission unit to execute the task, moves the mission unit to the task site, simulates the initiation of work when sufficient resources are on site, periodically updates task status until completion of the task (or until a gamer order to stop the task is encountered), and returns the mission unit to its origin.

(4) Airmobile Model. The Airmobile Model permits simulation of a variety of airmobile operations. To maintain a high degree of flexibility in application of the model, the simulation depends upon the gaming staff for most of the general planning and decision making prior to execution of an airmobile operation. These plans are relayed to the model by a set of

DSL orders. Activities actually simulated within the model include allocation of transport and escort aircraft to conduct the operation, staging and loading of the airmobile force, the actual airmobile movement, attrition of the airmobile column while in flight to and from the objective area, suppression of air defenses by escort aircraft, deplaning at a landing zone, refueling and rearming of aircraft, and the release of aircraft from operational control of the airmobile force.

(5) Combat Service Support Model. This model simulates the resupply of manpower and materiel to units within the DIVWAG system. The model deals with personnel replacements, replacement of major items of equipment, and resupply of critical consumables such as food (class I), fuel (class III and IIIA), barrier materials (class IV), and ammunition (class V).

(a) Replacement of personnel and major items is accomplished once for each simulated day of combat. Availability of replacement personnel and major end items is on a daily basis, input by the gamer, with available assets accumulating over time; i.e., assets not used on previous days are available in addition to those available for the current time. Requirements are based on unit losses, represented by the authorized unit level of personnel and major items less the quantities on hand within the unit at the time of the replacement action. First priority for replacements and major end items is to front line maneuver units, second priority to reserve maneuver battalions and all artillery units, and third priority to all other units. If sufficient replacements or major end items are not available to fill the needs within a unit priority group, each unit receives a pro rata share of available resources based on amounts required by all units within the priority group. Replacement and major end items arrive at the receiving units after an appropriate travel delay.

(b) The treatment of resupply of consumables within the Combat Service Support Model is conceptually similar to treatment of replacement of personnel and major items. Implementation differs to account for the following:

1. No limitation is placed on quantities of consumables available to the force. In the case of consumables, the primary limiting factor is the availability of transportation to move the materiel from various supply points to the consumer. The model treats movement of consumables through a series of supply points from the nominal point of entry into the force to the using unit. The model uses either a unit distribution or a supply point distribution method on each leg of the supply chain, depending upon the supply class of the consumable and the nature of the receiving unit at each node.

2. To accomplish a more continual flow of consumables, resupply requirements are determined and actions initiated on a more frequent basis than with replacements. The model currently uses a 2-hour cycle for all consumables except class I, which is on a once-a-day cycle. (As experience is gained with the model, some appropriate cycle between the extremes of hourly and daily requirement determination should be established.)

3-12

_3._ A request for resupply of consumables is generated if the quantity in the unit trains is less than a fixed percentage of the authorized amount in trains. That percentage is currently set at fifty percent.

4. PROGRAM SIZE. The DIVWAG model programs, including the five processors and associated utility programs, consist of 96,900 FORTRAN source cards.

CHAPTER 4

COMPUTER SYSTEM REQUIREMENTS

The minimum computer system requirements for execution of the DIVWAG model are listed below.

Core storage capacity	124,000 words (octal)
Magnetic tape drives	2
Magnetic disk capacity	3,000,000 words (decimal)
Printer	1
Card reader	1
Software features	FORTRAN compiler (ANSI)[1]
	Overlay loader (2 levels)
	Mass storage input/output

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1. American National Standards Institute Incorporated, American National Standard FORTRAN, ANSI X 3.9; 1966.

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